

Claims

[c1] A process for producing hydrogen, comprising:

- catalytically reforming a first hydrocarbon portion with steam and air in an autothermal reactor to produce a first syngas effluent at a temperature from 650° to 1050°C;
- supplying the first syngas effluent to a reforming exchanger;
- passing a second hydrocarbon portion with steam through a catalyst zone in the reforming exchanger to form a second syngas effluent;
- discharging the second syngas effluent from the catalyst zone adjacent the inlet to form a syngas admixture with the first syngas effluent;
- passing the admixture across the catalyst zone in indirect heat exchange therewith to cool the admixture and heat the catalyst zone;
- collecting the cooled admixture from an outlet of the reforming exchanger;
- shift converting the admixture to obtain a carbon dioxide-rich gas stream lean in carbon monoxide;
- and
- separating the carbon dioxide-rich gas stream to

form a hydrogen-lean, mixed gas stream comprising nitrogen and carbon dioxide and a hydrogen-rich product stream.

- [c2] The process of claim 1, wherein the mixed gas separation comprises membrane separation.
- [c3] The process of claim 1, wherein the mixed gas separation comprises pressure swing adsorption.
- [c4] The process of claim 1, wherein the catalyst zone comprises catalyst tubes, the process further comprising:
 - supplying the first syngas effluent to a shell-side of the reformer;
 - supplying the second hydrocarbon portion with steam through the catalyst tubes;
 - discharging the second syngas effluent from the catalyst tubes adjacent the shell-side inlet to form the syngas admixture.
- [c5] The process of claim 1 wherein the autothermal reformer is operated with excess air.
- [c6] The process of claim 1 wherein the carbon dioxide-rich gas stream from the shift conversion comprises a molar ratio of hydrogen to nitrogen less than 3.
- [c7] The process of claim 1 wherein the mixed gas separation

is free of cryogenic separation.

- [c8] The process of claim 1 wherein the process is free of air separation.
- [c9] The process of claim 1 wherein a proportion of the first hydrocarbon portion relative to a total of the first and second hydrocarbon portions is from 55 to 85 percent.
- [c10] The process of claim 1 wherein a proportion of the first hydrocarbon portion relative to a total of the first and second hydrocarbon portions is from 60 to 80 percent.
- [c11] The process of claim 1 wherein the hydrogen product stream has a purity of at least 70 volume percent.
- [c12] The process of claim 11, wherein the hydrogen product stream has a purity of from 90 to 99.5 volume percent.
- [c13] The process of claim 1, wherein the hydrogen product stream has a purity of at least 95 volume percent.
- [c14] The process of claim 1, wherein the hydrogen product stream has a purity of at least 97 volume percent.
- [c15] The process of claim 1, wherein the hydrogen product stream has a purity of at least 98.5 volume percent.
- [c16] A process for generating an electrical current comprising the process of claim 1 and supplying the hydrogen-rich

product stream to a fuel cell.

[c17] A hydrotreating process comprising the process of claim 1 and supplying the hydrogen-rich product stream to a hydrotreater.

[c18] Apparatus for preparing syngas, comprising:

- autothermal reactor means for catalytically reforming a first hydrocarbon portion with steam and air to produce a first syngas effluent at a temperature from 650° to 1050°C;
- means for supplying the first syngas effluent to an inlet of a reforming exchanger;
- means for passing a second hydrocarbon portion with steam through a catalyst zone in the reforming exchanger to form a second syngas effluent;
- means for discharging the second syngas effluent from the catalyst zone adjacent the inlet to form a syngas admixture with the first syngas effluent;
- means for passing the admixture across the catalyst zone in indirect heat exchange therewith to cool the admixture and heat the catalyst zone;
- means for collecting the cooled admixture from an outlet from the reforming exchanger;
- means for shift converting the admixture to obtain a carbon dioxide-rich gas stream lean in carbon monoxide; and

means for separating the carbon-dioxide-rich gas stream to form a hydrogen-lean, mixed gas stream comprising nitrogen and carbon dioxide and a hydrogen-rich product stream.

- [c19] The apparatus of claim 18, wherein the separation means comprise a pressure swing adsorption unit.
- [c20] The apparatus of claim 18, wherein the separation means comprise a membrane separator.
- [c21] The process of claim 1, wherein the reforming, shift conversion and mixed gas separation comprise a process pressure from 10 to 200 bars.
- [c22] The process of claim 21, wherein the reforming, shift conversion and mixed gas separation comprise a process pressure of at least 30 bars.
- [c23] The process of claim 1, further comprising compressing air to the catalytic reforming with a gas turbine drive and recovering heat from exhaust from the gas turbine.